SOURCE FOR THERMAL PHYSICAL VAPOR DEPOSITION OF ORGANIC ELECTROLUMINESCENT LAYERS

FIELD OF THE INVENTION

The present invention relates to a deposition source for thermal physical vapor deposition of organic electroluminescent layers, and particularly to a deposition source capable of forming a uniform electroluminescent layer on the entire surface of a substrate by compensating increase of the distance between a deposition material and a heating means (or the substrate) from change of the thickness of the deposition material.

BACKGROUND OF THE INVENTION

Thermal physical vapor deposition process, which is one of the processes for depositing an organic electroluminescent device, is a technique to coat an electroluminescent layer on a substrate in a housing with vaporized deposition material. In the deposition process, the deposition material is heated to the point of vaporization and the vapor of the deposition material is condensed on the substrate to be coated after the deposition material is moved out of the deposition source. This process is carried out with both deposition source holding the material to be vaporized and substrate to be coated in a vessel with the pressure

range of 10^{-7} to 10^{-2} Torr.

Generally speaking, the deposition source to hold the deposition material is made from electrically resistant materials whose temperature is increased when electrical current is passed through walls (member). When the electrical current is applied to the deposition source, the deposition material inside is heated by radiation heat from the walls and conduction heat from contact with the walls. Typically, the deposition source is in the shape of box with aperture to allow vapor efflux toward the direction of the substrate.

Thermal physical vapor deposition source has been used to vaporize and deposit onto the substrate layers comprised of a wide range of materials, for example, organics of low temperature, metals, or inorganic compounds of high temperature. In the case of organic layer deposition, the starting material is generally powder. Organic powder has been recognized as giving a number of disadvantages for this type of thermal vaporization coating. First, many organics are relatively complex compounds (high molecular weight) with relatively weak bonding, and so intensive care must be taken to avoid decomposition during the vaporization process. Second, the powder form can give rise to particles of non-vaporized electroluminescent materials. The particles leave the deposition source with vapor and are deposited as undesirable lumps on the substrate. Such lumps are also commonly referred to as particulate or particulate inclusion in the layers formed on the substrate.

Further exacerbation is found in that the powder form has a very large surface area enough to support water sucked in or absorbed or volatile organics, and the volatile organics can be released during heating and can cause gas and particulates to be thrown outward from the deposition source toward the substrate. Similar considerations pertain to materials which are melted before vaporization and form droplets erupted to the substrate surface.

These unwanted particulates or droplets may result in unacceptable defects in products, particularly in electronic or optical products, dark spots may appear in images, or shorts or opens may result in failures within electronic devices.

Organic deposition apparatuses have been proposed to heat the organic powder more uniformly and to prevent the bursts of particulates or droplets from reaching the substrate. Many designs for complicated baffling structures between the source material and the vapor efflux aperture have been suggested to ensure vapor exits.

FIG. 1 is a schematic sectional view showing the inner structure of a conventional apparatus for depositing an organic electroluminescent layer, and shows a deposition source **10** mounted in a vacuum chamber **13** of the deposition apparatus and a substrate **12** located above the deposition source **10**. The substrate **12** to be coated with the organic electroluminescent layers is mounted to an upper plate **13-1** of the chamber **13**, and the deposition source **10** to have a deposition material **20** (organic material) is mounted on a

thermally insulating structure **14** fixed to a bottom wall **13-2** of the chamber **13**.

FIG. 2a is a sectional view showing the inner structure of the deposition source shown in FIG. 1, and shows that a baffle **11B** is provided in the deposition source **10** to prevent particulates or droplets contained in the vapor of the deposition material **20** from directly exiting through a vapor efflux aperture **11C** formed on the top plate **11A** of the deposition source **10**. The baffle **11B** corresponds to the vapor efflux aperture **11C** and is fixed to a number of support rods **11B-1** fixed to the top plate **11A** of the deposition source **10** to maintain certain space from the top plate **11A**.

The deposition apparatus using the deposition source **10** with the above structure has a heater or a heating means on (or under) the top plate **11A**, or is constructed for the top plate **11A** to have a heater in order to transfer heat to the deposition material **20** located around the center away from the side wall **11D**. Thus, the heat generated at the side wall **11D** as well as from the top plate **11A** is transferred directly to the deposition material **20** so that the deposition material **20** is heated and vaporized. The vapor of vaporized deposition material **20** is moved along the surface of the baffle **11B** and deposited on the substrate **12** (in FIG. 1) after exit through the vapor efflux aperture **11C**.

FIG. 2b is a sectional view showing the change of distance between the top plate of the deposition source in FIG. 1 and the deposition material after the deposition is processed

for a certain amount of time. Thus, FIG. 2b shows a state that the distance between the top plate **11A** and the surface of the deposition material **20** is increased.

As explained above, the quantity of the deposition material **20** received in the deposition source **10** is decreased gradually by heating and vaporizing reactions in progressing the deposition process also the thickness of the deposition material **20** is decreased. Thus, in a certain amount of time, the initial distance (**A** in FIG. 2a) between the top plate **11A** and the surface of the deposition material **20** in the deposition source is remarkably increased (**a** in FIG. 2b).

Due to increase of the distance between the top plate **11A** and the surface of the deposition material **20**, the heat transfer path is increased so that the deposition rate (that is, vaporization rate of the deposition material) set at the initial stage is decreased. Thus, in order to maintain the initially-set deposition rate, the temperature of the top plate **11A** acting as the heater heating the deposition material **20** is needed.

In particular, while the deposition process is progressed, the distance between the top plate **11A** and the surface of the deposition material **20** is increased. Under this situation, the sufficient heat generated at the top plate **11A** cannot reach the deposition material **20**, and so the deposition material located on the center is not vaporized though the heat generated from the side wall **11D** is supplied. Consequently, if the input amount of the deposition material

20 is high (that is, the thickness of the deposition material **20** is high), it is difficult to expect that all the deposition material is vaporized.

Also, the distance between the substrate **12** and the deposition material **20**, which is directly related to the uniformity of deposition layer, is increased to result in change of the deposition characteristics in time.

Low molecule organic electroluminescent material contains a large amount of organic material unstable to heat, and causes a problem of lowering the characteristics of the organic electroluminescent material by inducing resolution or change of the material characteristics due to excessive radiant heat in the deposition process. In addition, additional processes for cooling the chamber, exhausting the vacuum pressure, and re-vacuumizing are required to supply new deposition material to replenish the exhausted deposition material because the deposition process is conducted under high vacuum condition. Such additional processes cause loss of the process time.

In order to solve these problems, it is desirable to maintain uniformly the initial deposition characteristics (for example, vaporization rate of the deposition material) in supplying more deposition material in the deposition source at a time.

On the other hand, in the deposition source **10** with the structure shown in FIG. 2a and FIG. 2b, the side wall **11D** acts as a heating unit (for example, structure which coils are

wound around the side wall **11D**). As shown in FIG. 1, however, since the sidewall **11D** is exposed to the exterior, the thermal efficiency is lowered because all heat generated at the side wall **11D** is not transferred to the deposition material **20** and some heat is radiated to the exterior.

In addition, as describe above, in progressing the deposition process, the deposition material **20** supplied in the deposition source **10** is consumed, and so the thickness of the deposition material **20** is decreased. Thus, heat is generated at the sidewall **11D** corresponding to the portions without the deposition material and is not transferred directly to the deposition material, which contributes to energy waste.

Another drawback of the deposition source **10** is that the heat generated at the top plate **11A** and the side wall **11D** is not sufficiently transferred to the deposition material **20** located at the lower portion of the deposition source **10**, that is, the deposition material **20** adjoining the surface of the bottom wall **11E**. As a result, all of the deposition material **20** is not heated and vaporized. Particularly, depending on positions within the deposition source **10**, the temperature of each deposition material **20** becomes different, that is, thermal gradient within the deposition source. Therefore, it is difficult to form a uniform deposition layer on the substrate.

SUMMARY OF THE INVENTION

An object of the present invention is to provide the deposition source which can compensate change of the distance between the heating means and the surface of the deposition material caused by decrease of the thickness of the deposition material according to consumption of the deposition material in the deposition process for the purpose of solving problems caused by increase of the distance between the top plate (heating means) of the deposition source and the surface of the deposition material supplied into the deposition source from the deposition process.

Another object of the present invention is to provide the deposition source which can enhance thermal efficiency through preventing heat generated at the heating means from exiting to the exterior by adding a heat-cutting function.

Further, another object of the present invention is to provide the deposition source for forming organic electroluminescent layers which can obtain a uniform deposition layer by minimizing factors of temperature change and by efficiently using all the deposition material through supplying heat to the deposition source adjoining the surface of the bottom wall.

The deposition source according to the present invention is installed in a chamber, heated by applied electric power to transfer heat to a vapor deposition material received

therein and applying a vaporized deposition material generated therein to a substrate to form deposition organic electroluminescent layers onto the substrate, and comprises a vessel consisted of a top plate on which a vapor efflux aperture is formed, a side wall, and a bottom wall; a heating means for supplying heat to the deposition material received in the vessel, the heating means being capable of moving vertically; and a means for moving said heating means, the moving means being operated in response to the signal of a sensing means on varied distances between the heating means and the surface of said deposition material. Thus, the heating means is moved downward by the moving means to maintain the distance between the heating means and the surface of the deposition material at an initially-set value when the thickness of the deposition material is decreased.

Another deposition source according to the present invention is installed in a chamber, to form deposition organic electroluminescent layers onto the substrate, by applying a vaporized deposition material generated therein to a substrate, by transferring heat to a vapor deposition material received therein, heated by applied electric power, and comprises a vessel consisted of a top plate on which a vapor efflux aperture is formed, a side wall, and a bottom plate, the bottom plate being capable of moving vertically; a heating means for supplying heat to the deposition material received in the vessel; and a means for

moving said bottom plate, the moving means being operated in response to the signal of a sensing means on varied distances between the heating means and the surface of the deposition material. Thus, the bottom plate is moved upward by the moving means to maintain the distance between the heating means and the surface of the deposition material and the distance between the substrate to be coated and the surface of the deposition material at an initially-set value when the thickness of the deposition material is decreased.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more clearly understood from the detailed description in conjunction with the following drawings.

FIG. 1 is a schematic sectional view of a conventional apparatus for depositing an organic electroluminescent layer.

FIG. 2a is a sectional view showing the structure of the deposition source shown in FIG. 1 prior to performing the deposition process;

FIG. 2b is a sectional view showing change of the distance between the top plate of the deposition source and the deposition material in FIG. 1 after the deposition process is performed for a certain period of time.

FIG. 3a is a sectional view of the deposition source according to the first embodiment

of the present invention.

FIG. 3b is a detailed view of part 3b in FIG. 3a.

FIG. 3c is a view showing relationship between the top plate of the deposition source and the deposition material after the deposition process is completed.

FIG. 4 is a sectional view of the deposition source according to the second embodiment of the present invention.

FIG. 5 is a sectional view of the deposition source according to the third embodiment of the present invention.

FIG. 6 is a sectional view taken along line 6-6 in FIG. 5.

FIG. 7 is a schematic perspective view showing relationship between the substrate and the deposition source according to the fourth embodiment.

FIG. 8a is a plane view of the substrate showing the initial state which the electroluminescent layer is deposited on the surface using the deposition source shown in FIG. 7.

FIG. 8b is a plane view of the substrate showing the state that deposition of the electroluminescent layer has been completed under the state that the deposition source (or substrate) shown in FIG. 7 has been moved.

FIG. 9a and FIG. 9b are schematic sectional views showing various shapes of the

deposition source according to the fourth embodiment of the present invention.

DETAILED DESCRIPTON OF THE INVENTION

Reference should be made to the drawings. The same reference numerals are used throughout the drawings to designate same or similar elements.

First Embodiment

FIG. 3a is a sectional view of the deposition source according to the first embodiment of the present invention. A deposition source **100** according to the first embodiment is a vessel consisted of a top plate **101**, a side wall **102,** and a bottom wall **103**. The deposition source **100** contains solid organic electroluminescent vapor deposition material **20** (hereinafter, referred to as "deposition material"). A vapor efflux aperture **101A** is formed on the top plate **101**. The function of the vapor efflux aperture **101A** is to discharge vapor of vaporized deposition material from the deposition source **100**. A baffle member **104** fixed to a lower surface of the top plate **101** corresponds to the efflux aperture **101A.**

The top plate **101** can act as a heating means (heater) for supplying heat to the deposition material **20** or a separate heating means can be placed on (or below) the top plate

101. In the description below, a case where the top plate **101** acts as a heating means will be explained as an example.

The most important feature of the first embodiment as shown in FIG. 3a is that the top plate **101** of the deposition source **100** can be vertically moved. A movement means **151** to move the top plate **101** is mounted to the top plate **101**.

The movement means **151** used in the deposition source **100** according to the first embodiment is a hydraulic or pneumatic cylinder. Two support brackets **154** fixed a the side wall of the chamber (**13** in FIG. 1) are extended above the deposition source **100**, and the cylinders **151** are mounted to each end portion of the brackets **154**. Rods **152** of each cylinder **151** are fixed to both sides of the top plates **101**, and therefore, each cylinder **151** does not have any effect on vapor efflux of the deposition material **20** through the aperture **101A** of the top plate **101**.

On the other hand, each cylinder **151** is controlled by a control means which is not shown in FIG. 3a, and the control means is connected to a sensing means **153** (for example, optical sensor) installed on the lower surface of the baffle **104** so that the control means can control each cylinder **151** according to a signal from the sensing means **153**.

FIG. 3b is a detailed view showing part **3b** in FIG. 3a. FIG. 3b shows partially the structure of the side wall **102** and the top plate **101** which can be vertically moved along the

side wall **102** of the deposition source **100**.

A number of vertical grooves **102-1** are formed on the inner surface of the side wall **102**, and protrusions **101-1** are formed on the outer circumference surface of the top plate **101**. Each protrusion **101-1** corresponds to each groove **102-1** and can be received in the corresponding groove **102-1** when the top plate **101** and the side wall **102** are assembled. Thus, when the top plate **101** is moved vertically, each protrusion **101-1** is moved along the corresponding groove **102-1**. Consequently, the top plate **101** can be moved smoothly in the vertical direction without any deviation to the side wall **102** from the initial location.

FIG. 3c is a view showing relationship between the top plate of the deposition source and the deposition material after the deposition process is completed. The function of the deposition source constructed as described above will be explained in reference to FIG. 3a and FIG. 3c.

As explained above, in the depositing process, the quantity of the deposition material **20** received in the deposition source **100** is decreased gradually by the heating and vaporizing action. Thus, the distance between the surface of the deposition material **20** and the top plate **101** is changed (increased). The sensing means **153** mounted on the lower surface of the baffle **104** senses this change of the distance between the surface of the deposition material **20** and the top plate **101,** and then transmits the sensed signal to the

control means.

The control means calculates the distance between the surface of the deposition material **20** and the top plate **101** (that is, sum of the distance between the surface of the deposition material **20** and the sensing means **153,** and the distance between the lower surface of the baffle **104** and the top plate **101**) on the basis of the signals transmitted from the sensing means **153**, and then compares the calculated distance with the initially-set distance (value).

As a result of the above comparison, if the distance between the surface of the deposition material **20** and the top plate **101** is changed, the control means operates each cylinder **151**. By operating each cylinder **151**, the rods **152** of each cylinder **151** are extended downward so that the top plate **101** fixed to the ends of the rods **152** is moved downward along the side wall **102**.

If the distance between the surface of the deposition material **20** and the top plate **101** becomes the same as the initially-set distance (A in FIG. 3a) by downward movement of the top plate **101**, that is, when the distance between the surface of the deposition material **20** and the top plate **101** calculated by the control means on the basis of the signals transmitted from the sensing means **153** becomes the same as the initially-set distance, the control means halts the operation of each cylinder **151**.

The downward movement of the top plate **101** caused by the control means and each cylinder **151** is continued during the deposition process. After vaporizing all of the deposition material **20**, the control means makes the rods **152** of each cylinder **151** return to the initial state as shown in FIG. 3a. Then, the top plate **101** of the deposition source **100** returns to its initial position, and thereafter, new deposition material is supplied to the deposition source **100**.

On the other hand, FIG. 3a and FIG. 3c show that the optical sensor **153** acting as the sensing means is installed on the lower surface of the baffle **104**, but the optical sensor **153** can be installed at any position including the lower surface of the top plate **101** as long as the optical sensor **153** does not hinder the deposition process and can sense the distance between the surface of the deposition material **20** and the top plate **101**.

Second Embodiment

FIG. 4 is a sectional view of the deposition source according to the second embodiment of the present invention. The entire structure of a deposition source **200** according to this embodiment is the same as that of the deposition source **100** shown in FIG. 3a and FIG. 3c. In this embodiment, a top plate **201** can act as a heating means (heater) for supplying heat to the deposition material **20** or a separate heating means can be placed on (or

below) the top plate **201**. In the description below, a case where the top plate **201** acts as a heating means will be explained as an example.

The most important feature of the deposition source **200** according to the second embodiment is that a bottom plate **203** can be moved vertically in response to change of the distance between the surface of the deposition material **20** and the top plate **201**.

As described above, the uniformity of the deposition layer to be formed on the surface of the substrate (**12** in FIG. 1) depends on change of the distance between the substrate **12** and the deposition material **20**. In the deposition source **100** shown in FIG. 3a, change of the distance between the top plate **101** and the deposition material **20** can be compensated by the vertical movement of the top plate **101**, but a means to adjust change of the distance between the substrate **12** and the deposition material **20** is not disclosed.

In order to compensate change of the distance between the substrate **12** and the deposition material **20**, the deposition source **200** according to this embodiment has the structure which the bottom plate **203** can be moved vertically along a side wall **202**.

A movement means **251** for moving the bottom plate **203** is mounted under the bottom plate **203** on which the deposition material **20** is located. The movement means used in the deposition source **200** according to the second embodiment is a hydraulic or pneumatic cylinder. The cylinder **251** is installed on a bottom wall **13-2** of the chamber **13** shown in

FIG. 1, a rod **252** of the cylinder **251** is passed through the bottom wall **13-2,** and the end of the rod **252** is fixed to the lower surface of the bottom plate **203**. However, the structure shown in FIG. 4 is merely an example, and so the cylinder having another structure can be installed.

In the this embodiment, the cylinder **251** is controlled by a control means which is not shown in FIG. 4, the control means is connected to a sensing means **253** (for example, optical sensor) so that the control means controls the cylinder **251** according to the signal transmitted from the sensing means **253**.

On the other hand, a number of vertical grooves are formed on the inner surface of the side wall **202**, and a number of protrusions are formed on the outer circumference surface of the bottom plate **203**. Each protrusion corresponds to each groove and can be received in the corresponding groove. Therefore, the bottom plate **203** can be moved smoothly in the vertical direction without any deviation to the side wall **202** from the initial location. This structure of the second embodiment is the same as that of the first embodiment as shown in FIG. 3c except difference of the member on which the protrusions are formed. Therefore, a further detailed description on the protrusions and grooves is omitted.

In the depositing process, the quantity of the deposition material **20** received in the deposition source **200** is decreased gradually by the heating and vaporizing actions. Thus,

the distance between the substrate (**12** in FIG. 1) and the deposition material **20** is increased (surely, the distance between the surface of the deposition material **20** and the top plate **201** is also increased, and the increased distance between the surface of the deposition material **20** and the top plate **201** is the same as the increased distance between the substrate **12** and the surface of the deposition material **20**).

The sensing means **253** mounted to a lower surface of a baffle **204** senses change of the distance between the surface of the deposition material **20** and the top plate **201**, and then transmits the sensed signal to the control means. The control means calculates the distance between the surface of the deposition material **20** and the top plate **201** on the basis of the signals transmitted from the sensing means **253**, and then compares the calculated distance with the initially-set distance.

As a result of the above comparison, if the distance between the surface of the deposition material **20** and the top plate **201** is changed, the control means operates the cylinder **251** installed under the bottom plate **203**. By operating of the cylinder **251**, the rod **252** of the cylinder **251** is extended upward so that the bottom plate **203** fixed to the end of the rod **252** is moved upward along the side wall **202**.

If the distance between the surface of the deposition material **20** and the top plate **201** becomes the same as the initially-set distance (**A** in FIG. 3a) by the upward movement of the

bottom plate **203**, that is, when the distance between the surface of the deposition material **20** and the top plate **201** calculated by the control means on the basis of the signals transmitted from the sensing means **253** becomes the same as the initially-set distance, the control means halts the operation of the cylinder **251**.

The upward movement of the bottom plate **203** caused by the control means and the cylinder **251** is continued during the deposition process. After vaporizing all of the deposition material **20**, the control means makes the rod **252** of the cylinder **251** return to the initial state. Then, the bottom plate **203** of the deposition source **200** returns to its initial position, and thereafter, new deposition material is supplied to the deposition source **200**.

On the other hand, FIG. 4 shows that the optical sensor **253** acting as the sensing means is installed at the lower surface of the baffle **204**, but the optical sensor can be installed at any positions including the lower surface of the top plate **201** as long as the optical sensor **253** does not hinder the deposition process and can sense the distance between the surface of the deposition material **20** and the top plate **201**.

In the deposition sources **100** and **200** according to the first and second embodiments as described above, when the thickness of the deposition material **20** caused by consumption thereof during the deposition process is changed, the distance between the surface of the deposition material **20** and the top plate **101** (the first embodiment) or the distance between

the surface of the deposition material **20** and the substrate **12** (the second embodiment) can be maintained at the initially-set distance by the movement of the top plate **101** (the first embodiment) or the bottom plate **203** (the second embodiment). Thus, an appropriate amount of heat is transferred to the deposition material **20** during the deposition process so that the deposition temperature of the deposition material **20** can be maintained uniformly and the optimum deposition rate can be maintained.

In the second embodiment, especially, the distance between the top plate **201** and the deposition material **20** as well as the optimum distance between the substrate and the deposition material are always maintained, and so it is possible to form a uniform deposition layer. Also, the deposition material adjoining the surface of the bottom plate **203** can be vaporized so that it is possible to minimize the residual of the deposition material.

In particular, in a case where the deposition material is supplied to the maximum, all of the deposition material can be vaporized, and the time loss caused by vacuuming, heating, and cooling processes to be performed in the deposition chamber after replenishing the deposition material can be minimized. Therefore, the second embodiment enables the depth of the deposition source to make deeper than the conventional depositional source, and so the quantity of the deposition material supplied to the deposition source can be maximized.

Third Embodiment

FIG. 5 is a sectional view of the deposition source according to the third embodiment of the present invention. The deposition source **300** according to this embodiment has a vessel consisted of a top plate **301** acting as the heating means, a side wall **302,** and a bottom wall **303**. The structure of the top plate **301,** on which a vapor efflux aperture **301A** is formed and to which a baffle member **304** is fixed, is the same as the top plates **101** and **201** of the deposition sources **100** and **200** of the first and second embodiments, respectively. Therefore, a further detailed description thereon is omitted.

The important aspect of the deposition source **300** shown in FIG. 5 is that a number of coils **C1**, **C2**, ...**Cn** as a heating means for transferring heat to the deposition material **20** are wound around the side wall **302,** and a casing **350** is located at the outer side of the side wall **302**.

A number of coils **C1, C2, ...Cn** are wound on the outer circumference surface of the side wall **302**. The uppermost coil **C1** coincides with the surface of the deposition material **20** received in the deposition source with the maximum height (thickness), and the lowermost coil **Cn** coincides with the surface of the bottom wall **303**.

The coils **C1, C2, ...Cn** are arranged for electric power to be individually applied thereto. A control means (not shown) controls the electric power applied to each coil **C1,**

C2, ...**Cn**, and the control means is connected to a sensing means **353** (for example, optical sensor) which is mounted to the interior of the deposition source.

The function of the coils **C1**, **C2**, ...**Cn** arranged and described as above is as follows.

In the early stage of the deposition process, the surface of the deposition material **20,** which is supplied into the deposition source **20** with the maximum height, coincides with the uppermost coil **C1**. At this time, electric power is applied to only the uppermost coil **C1,** not the other coils **C2**, ...**Cn,** by the control means. The upper side of the deposition material **20** is heated and vaporized by the heat generated at the top plate **301** acting as a heating means and by the heat generated at the uppermost coil **C1**.

In the depositing process, the quantity of the deposition material **20** received in the deposition source **200** is decreased gradually by the heating and vaporizing action (that is, decrease of the height of the deposition material **20**).

The sensing means **353** mounted on the lower surface of the baffle **304** senses change of the height of the deposition material **20,** and transmits the sensed signal to the control means. Then, the control means calculates the height of the deposition material **20** on the basis of the signals transmitted from the sensing means **353**. According to the calculated height of the deposition material **20**, the control means controls the electric power applied to the other coils **C1**, **C2**, ...**Cn**.

That is, when the height of the deposition material **20** is reduced and the surface of the deposition material **20** corresponds to the second coil **C2** positioned below the uppermost coil **C1**, the control means blocks the electric power applied to the uppermost coil **C1** and applies the electric power to the second coil **C2**.

In succession, if the surface of the deposition material **20** corresponds to the lowermost coil **Cn**, the control means applies the electric power to the lowermost coil **Cn** and blocks the electric power applied to the other coils **C1, C2 . . .**

As described above, in the depositing process, even though the height of the deposition material **20** is changed, any one coil to which the electric power is applied always corresponds to a portion of the deposition material **20** to which the heat generated by the top plate **301** is transferred. Therefore, it is possible to prevent the heat generated by the coils **C1**, **C2**, ...**Cn** from transferring unnecessarily to the portion of the deposition material which heating and vaporizing do not take place and the deposition material is not present.

On the other hand, the casing **350** located at the outer side of the side wall **302** prevents the heat generated at each coil **C1, C2**, ...**Cn** from radiating outward. Thus, most of the heat generated at each coil **C1, C2**, ...**Cn** is transferred to the deposition material **20** through the side wall **302** so that it is possible to minimize heat loss. Particularly, if the space formed between the side wall **302** and the outer casing **350** is filled with a thermal

insulation material, the heat radiation is prevented more effectively to minimize thermal gradient in the entire system. The reference numeral **350A** indicates the opening formed on the casing **350** for connecting power lines to the coils **C1**, **C2**, ...**Cn**.

More excellent adiabatic property can be obtained by forming the casing **350** with oxide or nitride of aluminum (Al), zirconium (Zr), silicon (Si), yttrium (Y), etc., having high thermal capacity.

Another feature of the deposition source according to this embodiment is shown in FIG. 6. FIG. 6 is a sectional view taken along the line 6-6 in FIG. 5 and shows a recess **303A** formed at the lower surface of the bottom wall **303** and a coil **C** received in the recess **303A**.

The recess **303A** is formed to the longitudinal (or widthwise) direction on the bottom wall **303**, and consists of many linear portions and connection portions connecting two neighboring linear portions. Thus, the single coil **C** is spread on the entire surface of the bottom wall **303**. Both ends of the coil **C** are connected to the power supply (not shown).

When the deposition process is performed, the electric power is applied to any one of the coils **C1**, **C2**, ...**Cn** wound around the side wall **302** as well as the coil **C** received in the recess **303A** of the bottom wall **303** (surely, the electric power is applied to the top plate **301** acting as a heating means). Therefore, the heat generated at the coil **C** received in the recess

303A of the bottom wall **303** is transferred to the deposition material adjoining the surface of the bottom wall **303**.

In the deposition source according to third embodiment as described above, in the processing the depositing process, even though a height of the deposition material is changed, the coil to which the electric power is applied is always corresponded to a portion of the deposition material to which heat generated by the top plate is transferred. Therefore, it is possible to prevent heat generated by the coils from transferring unnecessarily to a portion of the deposition material which is not heated and vaporized and a portion of the deposition source in which the deposition material is not present.

Also, the casing provided at the exterior of the side wall prevents the heat generated at the coils mounted to the side wall from radiating outward, and so most generated heat is transferred to the deposition material through the side wall to minimize thermal gradient in the entire system.

In addition, when an additional coil is provided at the bottom wall of the deposition source, sufficient heat can be transferred to the deposition material which is remotely located from the heating means (that is, the deposition material adjoining the surface of the bottom wall), and so all of the deposition material can be used effectively and a uniform deposition layer can be obtained.

Fourth Embodiment

FIG. 7 is a schematic perspective view showing relationship between the deposition source according to the fourth embodiment and the substrate. An inner structure of the deposition source **400** is not shown in FIG. 7.

The deposition source **400** according to this embodiment is consisted of a top plate **401** with certain length and width, a side wall **402,** and a bottom wall. A vapor efflux aperture **401A** is formed on the top plate **401**. An organic electroluminescent vapor deposition material is received in the space formed by the top plate **401**, the side wall **402,** and the bottom wall.

A feature of this embodiment is to constitute the deposition source **400** whose effective deposition length (that is, length **A** of the vapor efflux aperture **401A** of the top plate **401** actually contributing to the deposition process) is longer than, or the same as, the width **b** of the substrate **12** on which the electroluminescent layer is formed.

FIG. 8a is a plane view of the substrate showing the initial state that the electroluminescent layer is formed on the surface of the substrate by means of the deposition source **400** shown in FIG. 7. If the deposition source **400** as described above is used for forming the electroluminescent layer on the surface of the substrate **12**, the deposition

material's vapor is diffused through the aperture **400A** of the top plate **401**, and then dispersed and deposited uniformly on the surface of the substrate **12** over the entire width.

The more effective deposition process can be performed by moving the deposition source **400** constructed as described above or the substrate **20** to the longitudinal direction of the substrate. That is, when the deposition source **400** or the substrate **20** is moved horizontally (linearly) to the arrow direction shown in FIG. 8, the electroluminescent layer as shown in FIG. 8a is continuously deposited on the surface of the substrate **12** over the entire length. Ultimately, as shown in FIG. 8b showing the surface of the substrate on which the deposition of the electroluminescent layer is completed after moving horizontally the deposition source **400** or the substrate **12**, the uniform electroluminescent layer is formed on the entire surface of the substrate **12**.

On the other hand, each respective deposition source **100, 200, 300** and **400** described in the first to fourth embodiments has the inner space divided into the lower and upper portion, and the cross sectional surface of the lower portion is the same as that of the upper portion. Therefore, the flow rate of vapor of the deposition material at the lower portion is practically equal to the flow rate at the upper portion. Also, due to the large surface area of the upper portion of the deposition source, heat loss of the deposition material in the inner space is increased. In order to eliminate the above drawbacks, the present invention

modified the shape of the deposition source.

FIG. 9a to FIG. 9d are sectional views of the deposition sources, and show various shapes of the deposition source according to the present invention. Another feature of the deposition sources **500A**, **500B**, **500C**, and **500D** according to the present invention is that the sectional surface area of the upper portion at which the aperture is formed is smaller than that of the lower portion.

Though the sectional surface areas in a tube can be different in different positions, the quantity of flow is same anywhere in the tube, and therefore, the flow rate of a portion having smaller sectional surface area is higher than that of another portion having larger sectional surface area.

Consequently, just before diffusing vapor of the deposition material through the aperture, the flow rate of vapor at the upper portion having smaller sectional surface area is higher than that of vapor at the lower portion of the deposition source. Higher flow rate induces increase of the vapor's kinetic energy (molecules of the vaporized deposition material), and so the density and uniformity of the deposition layer formed on the substrate can be enhanced. Also, since the sectional surface area of the upper portion through which the vapor of the deposition material is diffused is small, heat loss outward can be minimized and the deposition source is not influenced by such exterior interference as change of

ambient temperature.

In the present invention, on the other hand, a material having higher thermal capacity than quartz, for example, oxide or nitride of aluminum (Al), zirconium (Zr), silicon (Si), or yttrium (Y), or composite material of at least two above, is used as the deposition source's material. The thermal capacity of these metal oxide or nitride is larger than organic material used as the deposition material (about 3:1), and therefore, the adiabatic property of the deposition source can be improved.

The preferred embodiments of the present invention have been described for illustrative purposes, and those skilled in the art will appreciate that various modifications, additions, and substitutions are possible, without departing from the scope and spirit of the present invention as disclosed in the accompanying claims.